The Effect of Surfactants in Dilute HF Solutions

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Abstract: The effect of adding surfactants to dilute-HF containing solutions was investigated. It was determined that different surfactants have an impact on particle and metals levels and may consequently affect properties such as minority carrier lifetime and thermal oxide thickness. The results also indicate that wafer particulate levels on bare silicon wafers decrease upon thermal oxide growth.

Introduction:

Dilute hydrofluoric acid (HF) is used in etching, stripping and cleaning thin silicon dioxide (<500 Angstrom) films. Although diluted HF is employed to decrease the etch rate it is not as controllable since hydrogen ions generated during the reaction of silicon with HF readily adsorb onto the silicon surface leading to non-uniform etching through micromasking [1]. Hence, surfactants have been incorporated to improve surface wetting and etch uniformity.

Experimental:

Prime 100-mm p-type silicon wafers were immersed sequentially in a modified RCA-1 followed by RCA-2 and finally in dilute HF (100:1) containing different surfactants. Metal and particle contamination levels were conducted prior and following a nominal 170 Angstrom thermal oxide growth. Electrical tests were performed on oxide-grown wafers only.

Results and Discussion:

A wafer control group consisting of the same sequence as dilute HF without the surfactant was included for comparison testing. After immersion in dilute HF, iron levels were elevated for Group B wafers as shown in Figure 1.

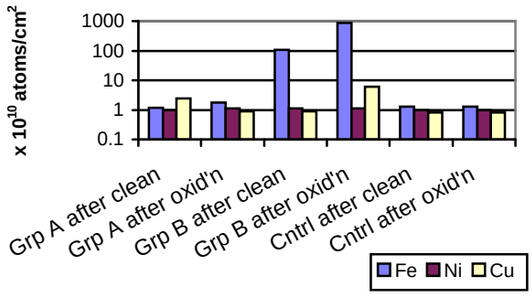

Figure 1. Wafer surface trace metal by TXRF

Certain wafer surface trace metal impurities exhibit opposite trends after dilute HF clean and thermal oxidation. TXRF analysis indicates that iron levels increase following oxide growth while copper levels vary with different surfactants (opposite trends as noted for Group A and B). As shown in Figure 2, particles were also elevated wafers in Group B after immersion in a dilute HF with surfactant.

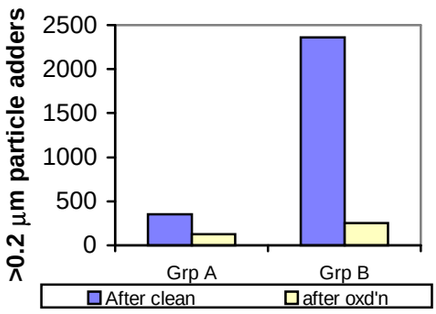

Figure 2. Particles on wafers

Particulate levels also decreased following thermal oxide growth. Figure 3 reveals that a thicker oxide is grown with Group B wafers.

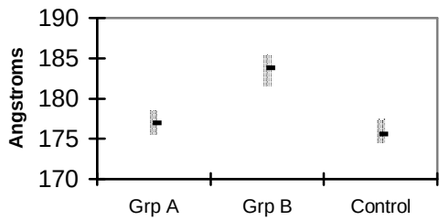

Figure 3. Thermal oxide thickness

In addition, the electrical characterization of the thermal oxide indicates reduced minority carrier lifetime associated with Group B wafers as shown in Figure 4.

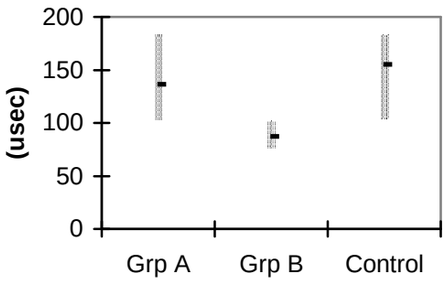

Figure 4. Minority carrier lifetime

The reduced lifetime is the result of higher iron concentration found on the thermal oxide and bare silicon.

Conclusion:

Addition of surfactants to dilute HF have been studied and shown to affect trace metals, particles, oxide thickness and minority carrier lifetime after a wet clean and thermal oxidation.

Reference:

1. Kikuyama, H. et. al., "Surface Active Buffered Hydrogen Fluoride Having Excellent Wettability for ULSI processing," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 3, No. 3, Aug. (1990)